ARL'S ACOUSTIC DATABASE

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ABSTRACT

The Acoustic Signal Processing Branch of Army Research Laboratory (ARL) has collected a significant amount of acoustic data over the past eight years. Acoustic data consists of the time-series signature of battlefield ground and air targets collected from a number of sensor arrays placed within detection range of the targets' travelling path. To cope with the growing data collected over the last few years, a multi-user client/server acoustic database has been developed. This database is an integral component of the ongoing Acoustic Automatic Target Recognition (ATR) effort. Data is currently centralized on the server and can simultaneously be accessed from client PCs over the ARL's Local Area Network via a custom-written user interface front-end program, ATRView. This front-end program features data entry and data query capabilities, as well as a suite of graphic tools to provide the user quick and easy means to select a portion of data of interest for viewing and downloading from the server to the client PC. The front-end program's main features are discussed in this report. Future plans include the capability for client PCs to access this database from locations outside ARL and the seamless integration of existing target detection, tracking, and identification algorithms into the front-end program.

1. Introduction

The Acoustic Signal Processing Branch of Army Research Laboratory (ARL) has maintained a significant collection of acoustic data for battlefield ground and air targets. Acoustic data is expensive to collect and crucial in the development and evaluation of target tracking and identification algorithms conducted by ARL researchers. ARL's data has also been requested by researchers from other government agencies, private organizations, and universities.

Data collected over the last eight years was recorded on digital audio tapes (DAT). Downloading this data onto a computer is a slow and tedious process. Locating a portion of data of interest for extraction adds further difficulty to this process. To retrieve data requires extracting target coordinates for start and end points, correlate them with the appropriate ground truth file, and set the recorder for data downloading accordingly. There is no other systematic means to retrieve data files and correlate ground truth to signature data. Furthermore, digital tapes have short shelf-life and need to be transferred to durable media such as CD's as soon as possible.

Recognizing the need for an automated centralized database to expedite data access and ease data maintenance of a growing data collection, the Acoustic Signal Processing Branch has developed a multi-user client/server acoustic database that runs on the ARL local area network. The database is managed by Microsoft SQL Server, a high-performance and secured relational database management system. Development costs have been kept at a minimum by utilizing existing computers in the laboratory.

This report gives an overview of the database design and highlights the main features of the user-interface program ATRView (version 1). It is not intended to be a user's manual nor a comprehensive document that describes in-depth technical aspects of the design.

2. Database Architecture Overview

The database consists of time series target signature data files and comprehensive information about these files. Associated with each run segment is a set of data files. A typical run consists of a number of sensor arrays strategically placed along the track where a target(s) travels on. A complete set of data files includes a signature data

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file for each of the sensor arrays, a ground truth file, a sensor survey file and a meteorological data file. On-line data is stored on the server's internal hard drives and a 500-CD jukebox. Off-line data is stored on CD's and removable hard drives. Comprehensive information about each run segment is kept in various database tables residing on one of the server's internal hard drives.

Users from client computers on the network communicate to the server via the custom-written front-end software ATRView which displays graphics and text information as well as playing the signature of the selected target to the speakers. Figure 1 depicts the client/server architecture of ARL's Acoustic Database.

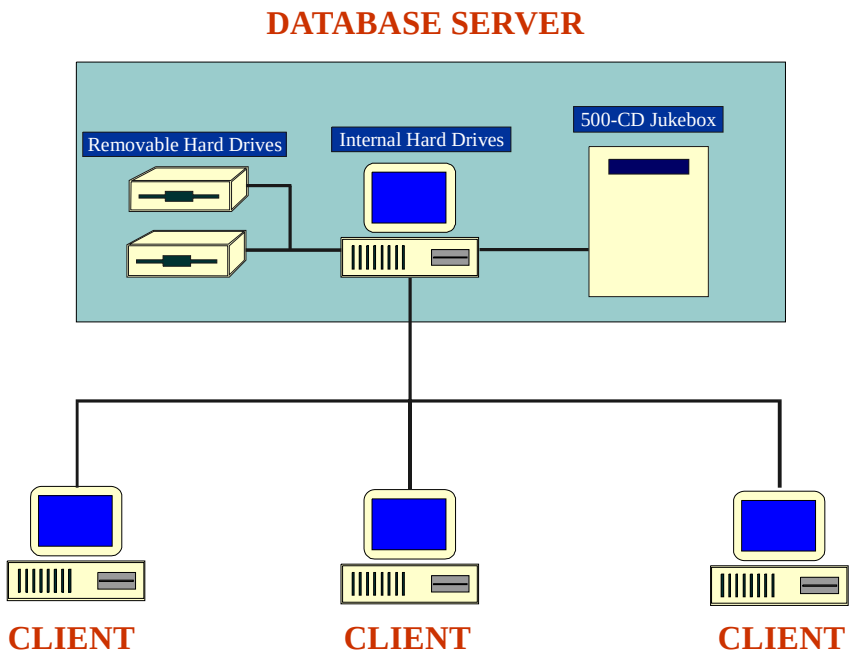

Figure 1. Client/Server Architecture of ARL's Acoustic Database

3. Database Server

The database server consists of a 450-MHz Pentium II PC with 256 Mbytes of RAM and two internal 10-GB hard drives where database's tables, image files and frequently-accessed data are stored. A 500-CD Pioneer jukebox equipped with four CD-ROM drives provides on-line data access. Off-line data is stored on 2-GB Jaz disks and CDs for unlimited storage capability.

The server runs under Windows NT Server 4.0 operating system and is dedicated to the tasks of running the database engine Microsoft SQL Server 6.5. Users from remote client computers can simultaneously access the database on the server. A Windows NT Server and an SQL Server user access license are required for each database connection. SQL Server is capable of handling hundreds of concurrent users without compromising its performance[1].

The jukebox management software DiskExtender is used to control the jukebox's operation and manage its file system so that the jukebox appears like a huge hard drive to the users. Signature data files and associated information are centrally stored on the server. The capability to modify the database requires access to an administrator's login ID and password. The administrator is responsible for designing of the database structure, setting users' access permissions, maintaining and backing up data.

[1] Heng Tan, Visual Basic/SQL Server Primer, ETN Press, Montoursville, PA (1995), p. 46.

4. Clients

A client consists of any PC running Windows 95, Windows 98, or Windows NT. A login ID and password are required for a client to connect to the server to query, view, and down load data files from the server. SQL Server is powerful and is dedicated solely to managing data. It is not equipped with an easy-to-use interface. To enable better communication between the user and the server, the Acoustic Signal Processing Branch has developed an innovative user-friendly Visual Basic front-end program. Residing on each client PC, this front-end program combines point-and-click operations, text, graphics and audio to provide the user an effortless means to interface to the server. The database design takes advantage of the client/server architecture by having both server and client share the workload, resulting in the combination of processing power from both ends of the system.

At a minimum, the server and client PCs should be equipped with software shown in Figure 2.

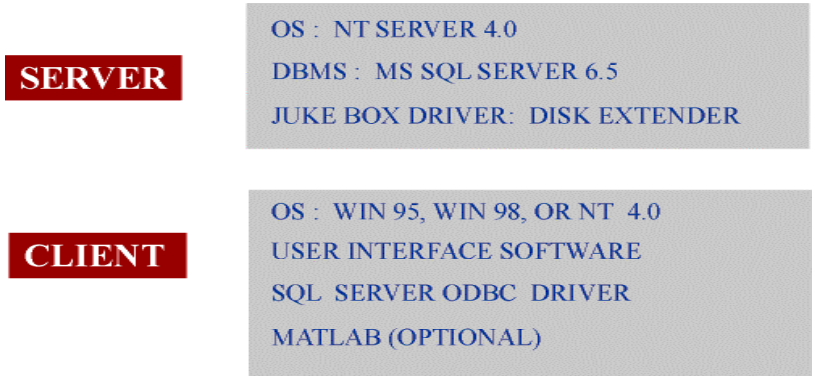

Figure 2. Software Requirements

5. Database User-Interface Program

Microsoft Visual Basic, Professional Edition, Version 6.0 was selected as the development language for the database user-interface program because it supports the development of commercial-quality Windows Graphical User Interface (GUI) applications. Other factors that support the choice of Visual Basic are: low cost (applications are distributed with no runtime fees), vendor stability and extensive third-party add-on products.

The user-interface program consists of three separate modules: data entry, file query and view/download tools. To execute the program, the user is required a valid user's (or administrator's) login ID and password. The data entry module is available to all users to view but database modifications can be performed only by users with administrator privileges.

5.1 Data Entry Module

Data Entry Module is the medium where the administrator accesses all database tables. Depending on the information they contain, tables are divided into four categories: file, target, sensor and data collection. Figure 3 shows the Data Entry Window where currently one of the ten records from table Ground_Info (table contains information of ground targets) is displayed. Table Ground_Info has been selected from the list of tables in the folder Targets for opening. The number of records in the table is indicated on the status bar at the bottom of the screen. The four buttons First, Prev, Next and Last enable maneuvering between records in the table. Records in a table can be sorted by any field such as Target_ID, Target, Class, etc. The edit buttons allow adding, modifying and deleting records in a table. The search utility is used to search for a record by any field. The Print Record button

generates a hard copy of the display record. Clicking the mouse's left button on the target picture will enlarge the picture on the screen.

The Data Entry Window only allows viewing and editing one table record at a time. At times, the administrator may need to view multiple records and make bulk changes. This capability is provided in the SQL Command Window where the administrator writes an SQL command to be passed to the server to query for results or make changes to several records in one table simultaneously. Figure 4 is a sample window that displays returned information from the server in respond to the SQL command SELECT.

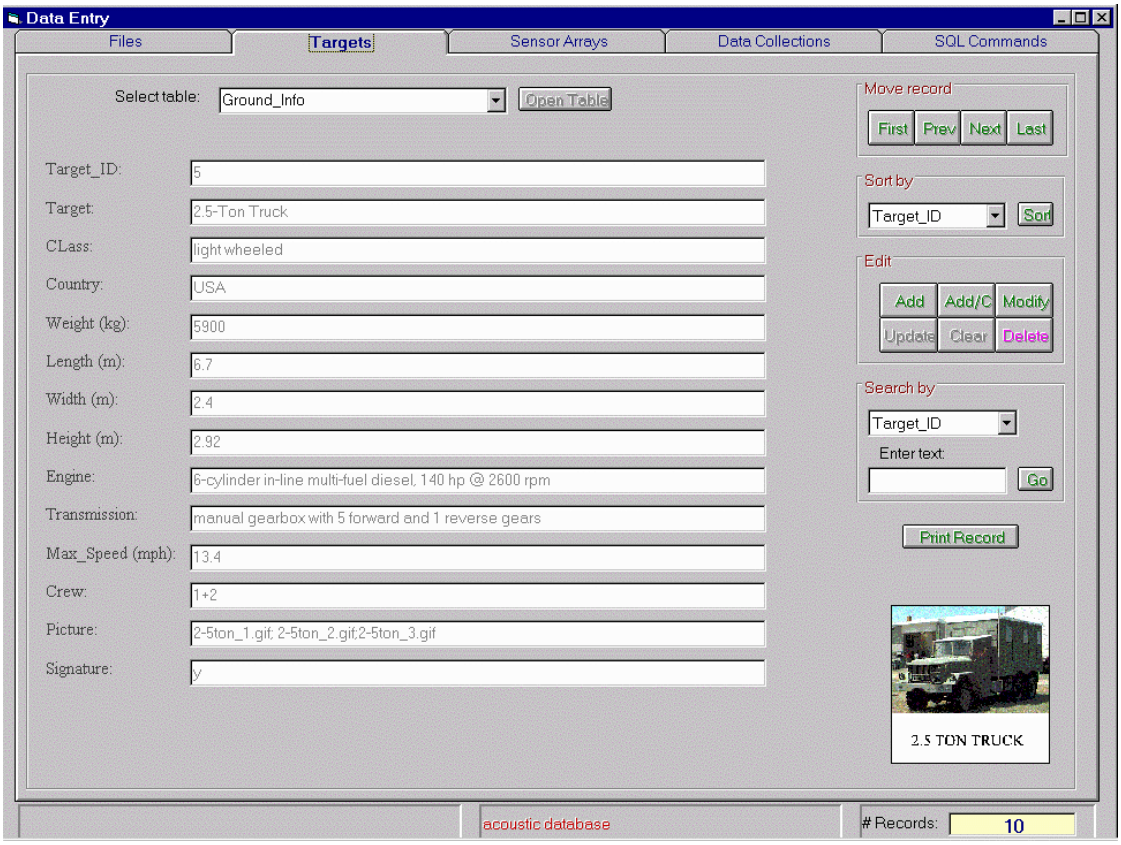

Figure 3. Data Entry Ground Target Window

5.2 Query Module

The query module is where the user searches for data files that satisfy selected criteria in four categories: target, sensor, data collection and meteorological condition. This easy-to-use user interface requires only point-and-click actions and minimum typing, as depicted in Figures 5 and 6. Figure 5 shows the Target-Select Window and Figure 6 shows the Sensor-Select Window. In both figures, the list boxes are populated with existing data in the database at the time the database is accessed. With new entries added to or deleted from the database, the list boxes' contents change accordingly.

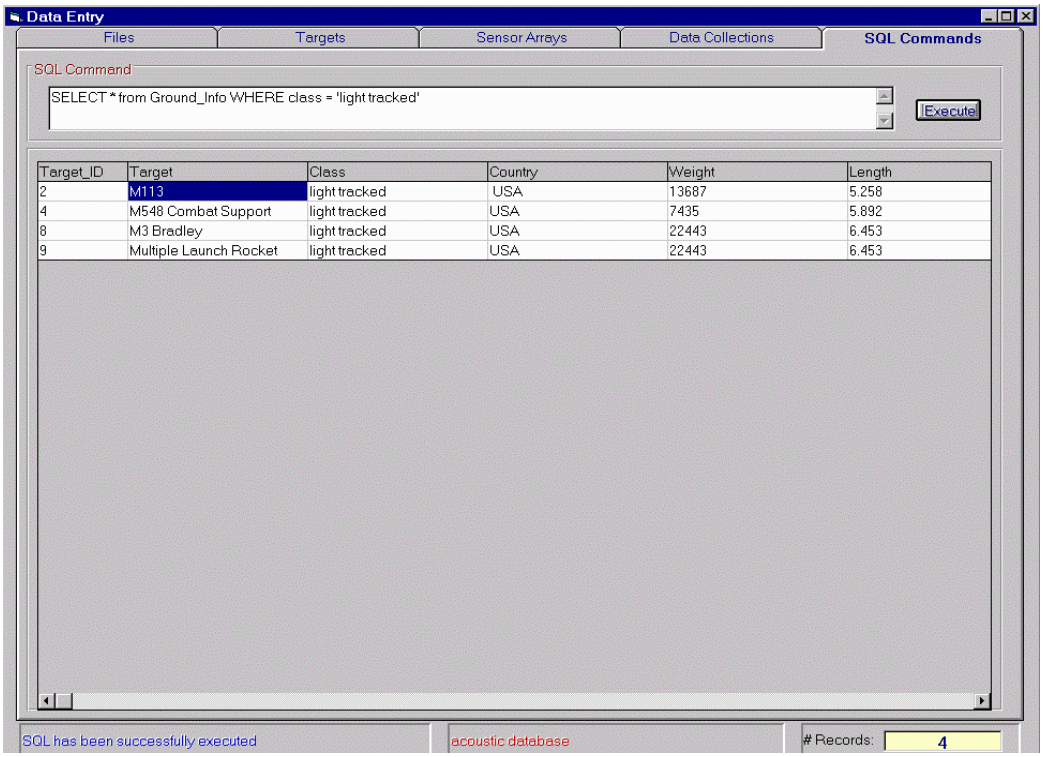

Figure 4. Data Entry SQL Command Window

To populate the Targets with Signatures and Targets without Signatures list boxes, the user in order: checks/unchecks classified checkbox, selects signature type, target category, country and class (Figure 5). Targets having signature data in the database and those without data are listed separately. Double clicking on a target name in either list box will open up a Target Information Window. An example of a Target Information Window is shown in Figure 7, where information about a HMMWV is displayed when double clicking the vehicle's name in the Targets with Signatures list box. Clicking the Print button on the bottom of the screen will output this screen to a printer connected to the client PC. The two separate list boxes allow the user to browse target information, yet they prevent the user from making queries on targets without signature data. This feature, thus, saves time that would have been wasted by searching for non-existent files.

For convenience, the user has an option of choosing the unit for speed in either miles per hour (mph) or kilometers per hour (kph) and unit for temperatures in either Celsius (^{o}C) or Fahrenheit (^{o}F). However, speeds and temperatures are entered in the database in kph and ^{o}C, accordingly.

If the user needs to repeat the query at a later time, he has an option to save the query setting in a file with the Save Query button. Clicking on the Load Query button will load the saved query into the query windows where it is ready to be used again or modified if necessary. To send the query to the server and receive the resulting list of files, the user clicks on the Run Query button.

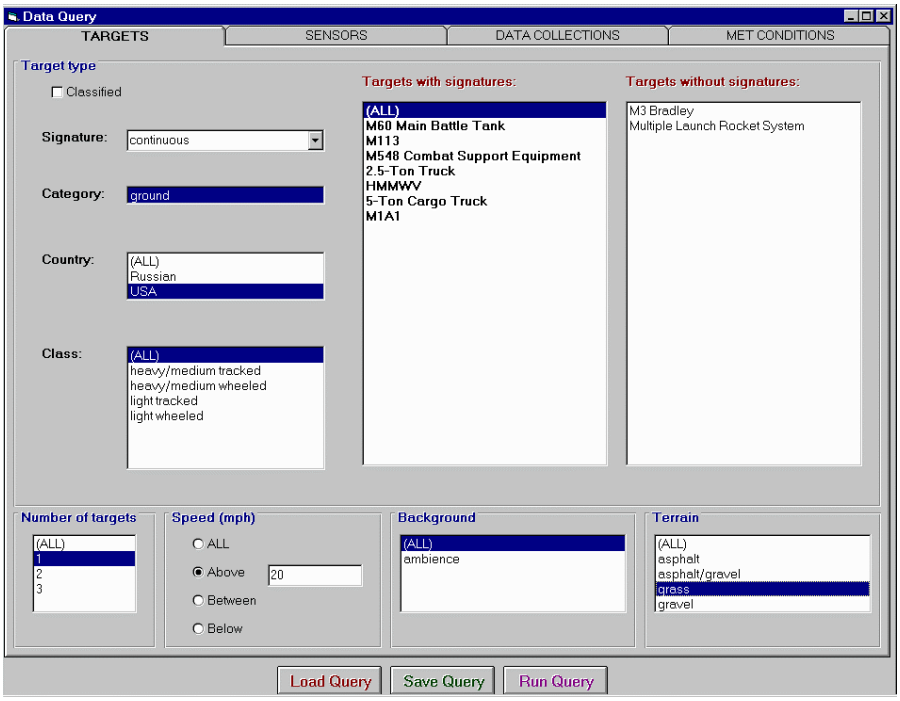

Figure 5. Target Select Window

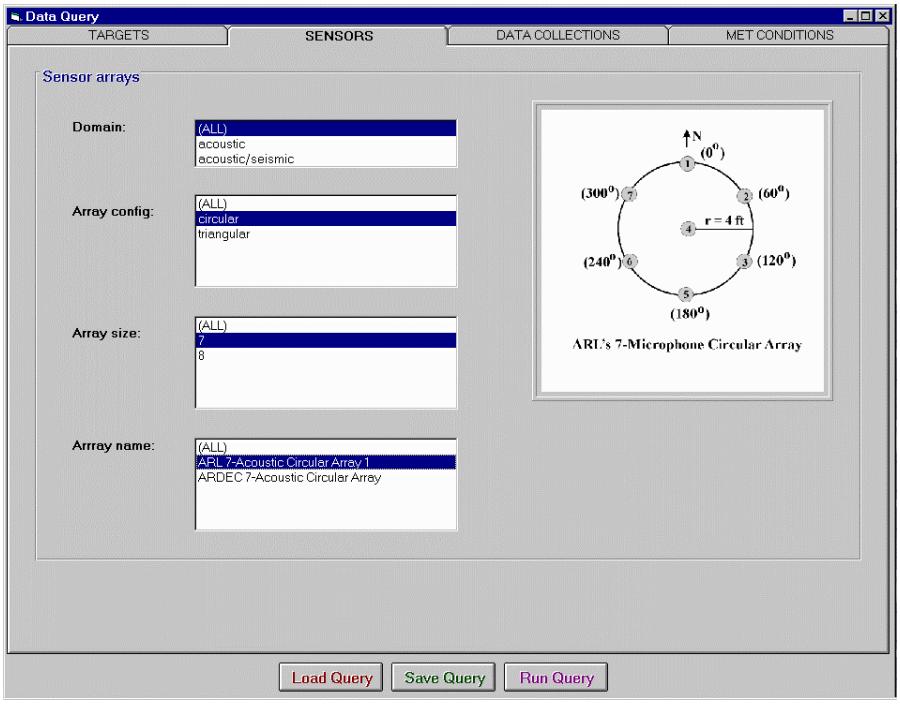

Figure 6. Sensor Array Select Window

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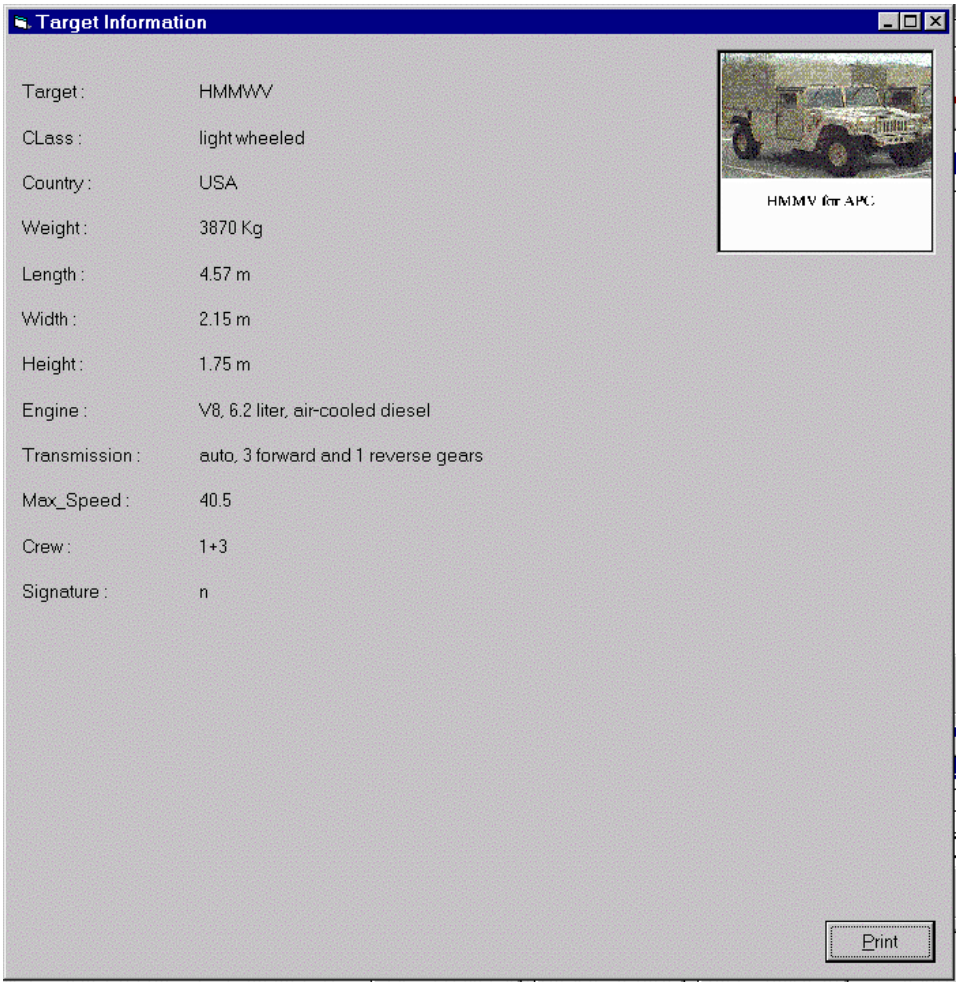

Figure 7. Target Information Window

Figure 8 is a sample window, which displays available files returned from the server. The list boxes labeled "Online Signature Files found" and "Offline Signature Files Found" contain online and offline signature filenames that meet the query's conditions. The Select Media list box lists labels of the media where offline files are stored. The user can choose to display offline files for select media.

The user can obtain general information about any file by double clicking on the filename in any list box. This action invokes the File Information Window as shown in Figure 9. Online and/or offline files that are of interest to the users can be selected and moved to the right list boxes to be saved in a text file for future reference. Files can be moved back and forth between right and left list boxes. Selecting the Save button will write the selected online and offline files into a text file.

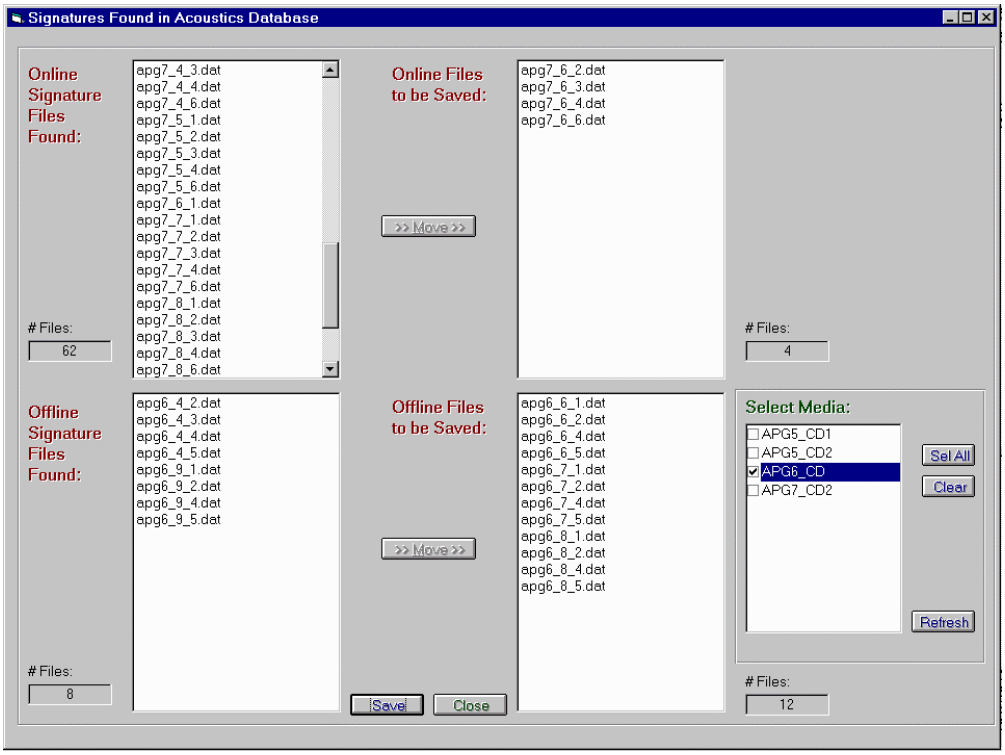

Figure 8. Query Result Window

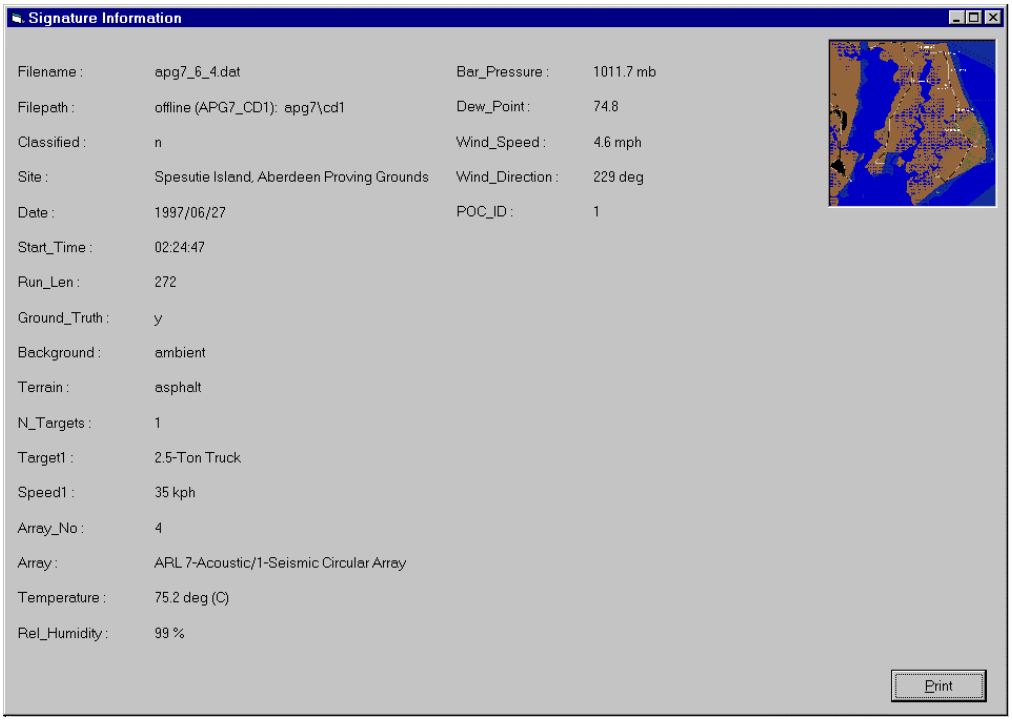

Figure 9. Signature File Information Window

5.3 Tools Module

The Tools Module is a suite of graphics tools, which enables the user to select the target's start and end positions on the track. The acoustic signal for this select portion of the run can be plotted in time and frequency domains and downloaded from the server to the client. Other implemented features will also be mentioned in this section.

5.3.1 Filename Convention

In order for the front-end program to systematically link related files together, a naming scheme has been defined as follows (an example filename is shown in parentheses):

- **Signature File** (binary): field test code name_run number_sensor array number.dat (apg8_15_3.dat)
- **Header File** (binary): field test code name_run number_sensor array number.hdr (apg8_15_3.hdr)
- **Information File** (text): field test code name_run number_sensor array number.ifo (apg8_15_3.ifo). This file is derived from the binary header file.
- **Ground Truth File** (text): field test code name_run number.gps (apg8_15.gps)
- **Sensor Survey File** (text): field test code name.sur (apg8.sur)
- **Met File** (text): field test code name_run number.met (apg8_4.met if this run has its own met file, or apg8_1to9.met if runs 1-9 share the same met file).
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5.3.2 Plot Descriptions

The Tools Module displays four types of plots: ground truth, time series signature, power spectral density and spectrogram.

Ground Truth Plot: A signature file is opened via Open List or Open File button. If target ground truth and sensor survey files exist for the open file, the ground truth plot is generated automatically. The ground truth plot in Figure 10 displays six sensors along the target track. The filename apg8_53_3.dat[2] on the status bar indicates run number 53 and array number 3. Array number 3 (of the open file) is highlighted in a different color from other sensors.

Clicking on the Play button on the left hand side of the Ground Truth plot will plot the targets as they move along the track from the beginning of the run until the end. The To and From sliders provide the option to manually select the start and end positions of targets. In Figure 10, the sliders have been moved to select the targets' start position at 275 sec and end position at 345 sec from the beginning of run. The two targets' start and end positions are indicated by the four dots, labeled 1s, 1e for target 1 and 2s, 2e for target 2. Each target is plotted in a different color. Double clicking the left or right mouse button on the plotting area will cycle through different label types: target number with start and end indication (1s, 1e, 2s, 2e), distance from target to highlighted sensor array, target UTM coordinates, line of bearing, and labels off.

Time Series Plot: The time series signature plot for the select channel is generated when clicking on the Plot Time button. The plot in Figure 10 is for the selected time range from 275 to 345 sec with a duration of 70 sec. A different time range can be selected with the sliders and the time series signature can be re-plotted using the Plot Time button.

Power Spectral Density Plot: The Power Spectral Density plot displays the frequency contents of the signature data at the second selected by the To slider. By moving the slider to another time point and clicking on the PSD Plot button, the Power Spectral Density is re-plotted at that second.

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[2] Vuong Anh Nguyen et al., Spesutie Field Test Log, 14-18 December 1998 (1999).

Spectrogram: The spectrogram for the selected time frame is plotted with the Spectro button as indicated in Figure 11. The 3-D spectrogram can be rotated 360 degrees to obtain the best viewing angle.

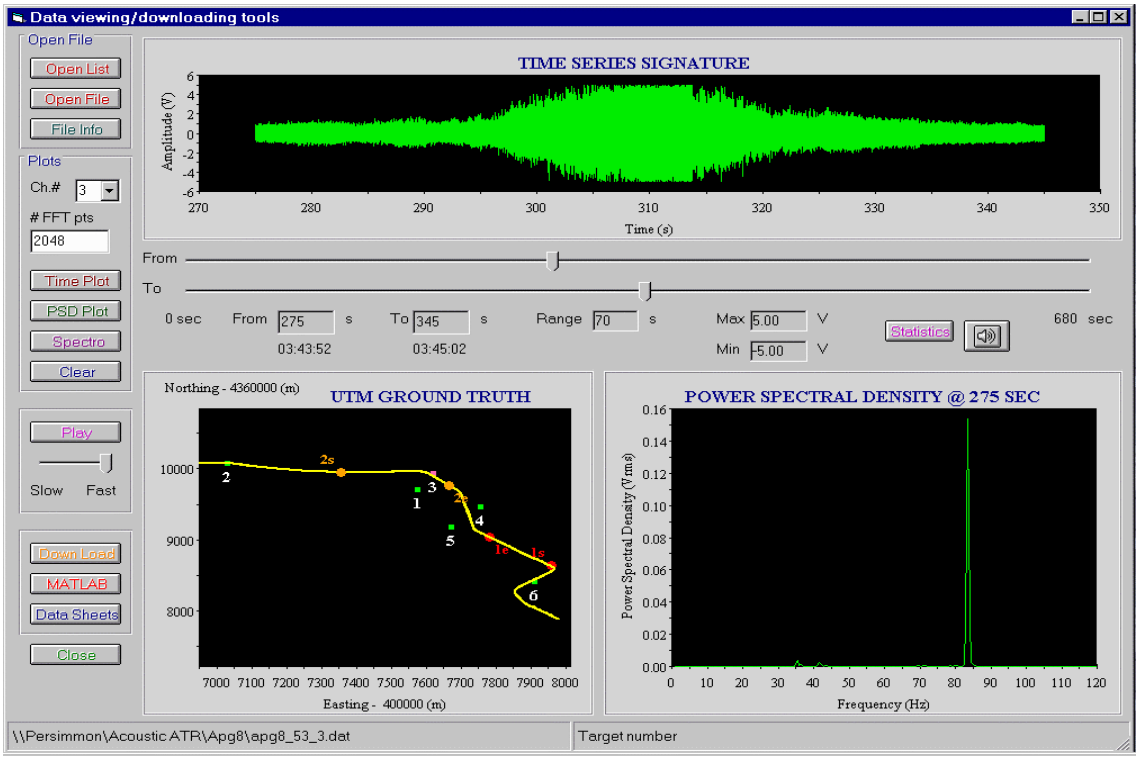

Figure 10. Tools Main Window

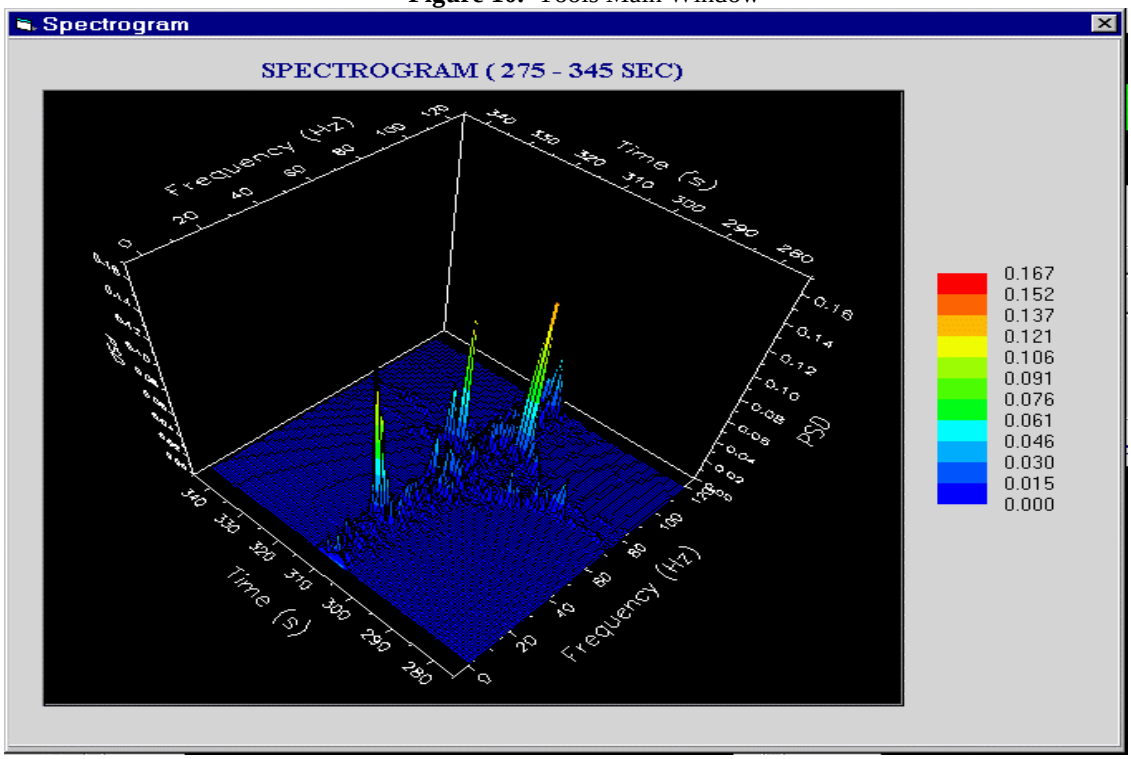

Figure 11. Spectrogram

5.3.3 File Header Viewer

Header information for each signature file is stored in a binary header file. The advantage of having the header file separate from the data file provides the capability to easily modify the header information due to it size (< 1 KB) as compared to having it combined with the data file (tens of MB). Some database parameters (target type, sensor array type, test site, etc.) use ID numbers instead of actual names for ease of modifications and also for security purposes.

The information stored in the header file can be viewed by clicking on the File Info button. This will open up the Header Information Window. Figure 12 is an example of this window, which shows sensor/calibration information for the open file (from APG7 field test)[3]. The Header information is organized in different folders for ease of viewing. A text version of the header can be output to the printer or saved in a file with the .ifo extension.

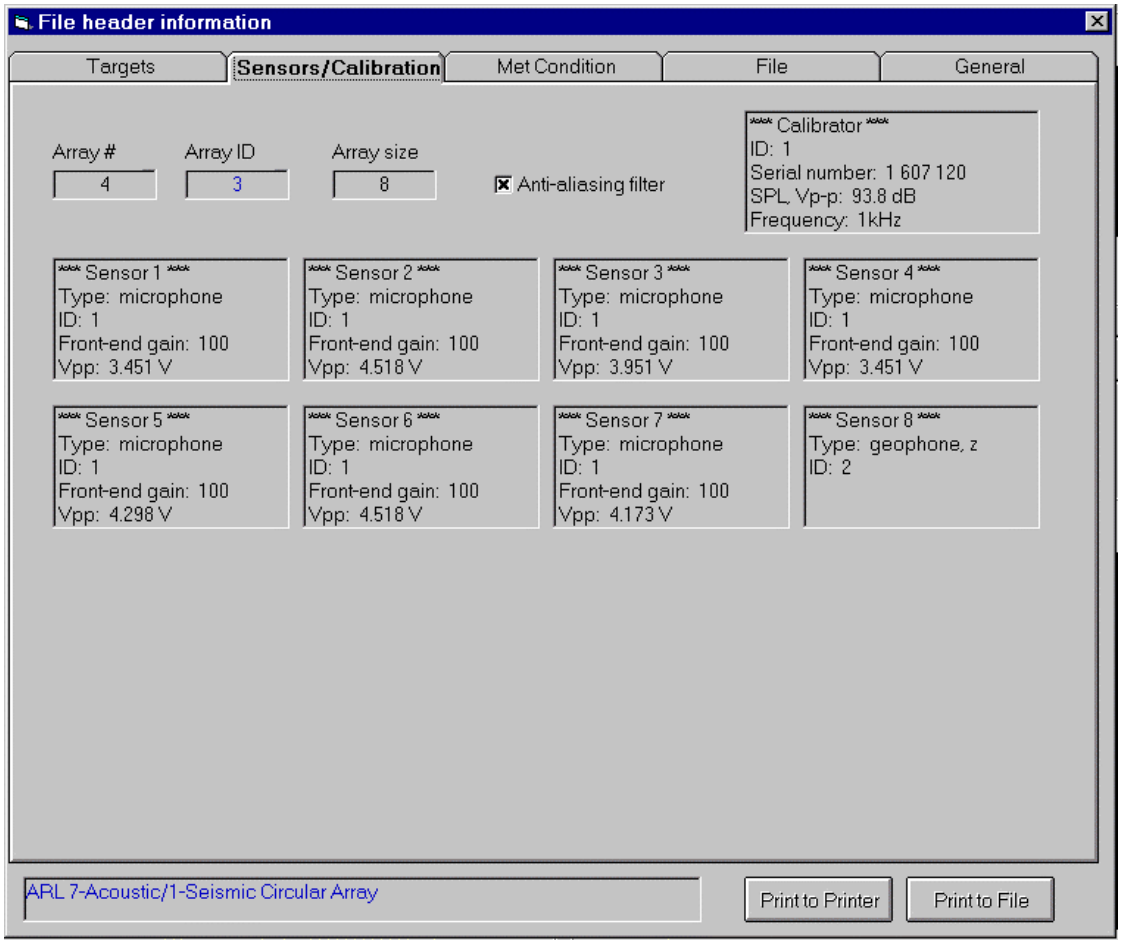

Figure 12. File Header Window

5.3.4 All-Channel Statistics

To quickly view the statistics for all microphone/geo-phone channels, click on Statistics button. From the statistics information, a bad channel can be identified quickly. Figure 13 shows an example of the statistics for the selected time range.

5.3.5 Audio Playback

[3] Vuong Anh Nguyen et al., Spesutie Field Test Log, 26-27 June 1997 (1998).

The plotted time series signature can be heard from the PC speakers by clicking on the button with the speaker icon. Due to the low-frequency contents of the targets' signature, a good-quality set of speakers with an appropriate frequency response is needed for generating high-fidelity sounds.

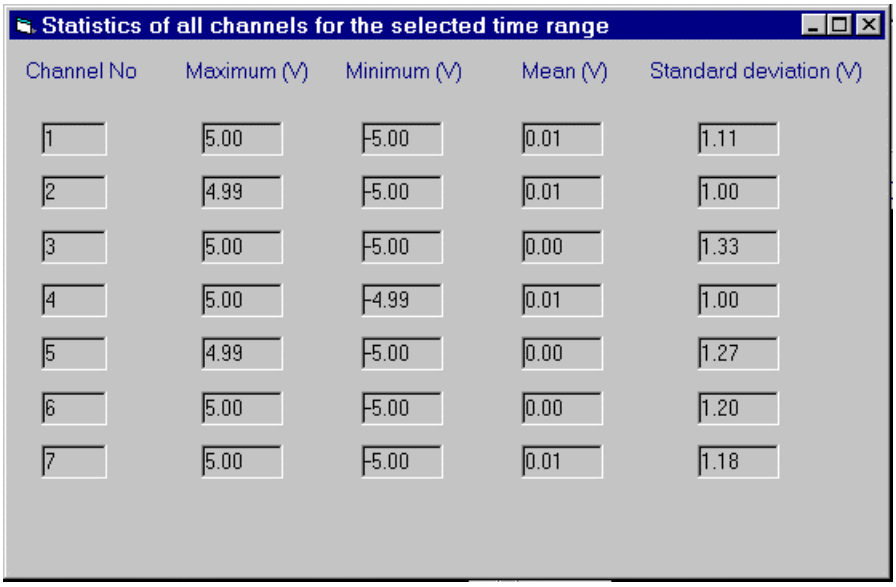

Figure 13. Signature Statistics

5.3.6 Data Sheets

For convenience, data sheets for microphones, geo-phones and calibrators are included. A sample data sheet is shown in Figure 14.

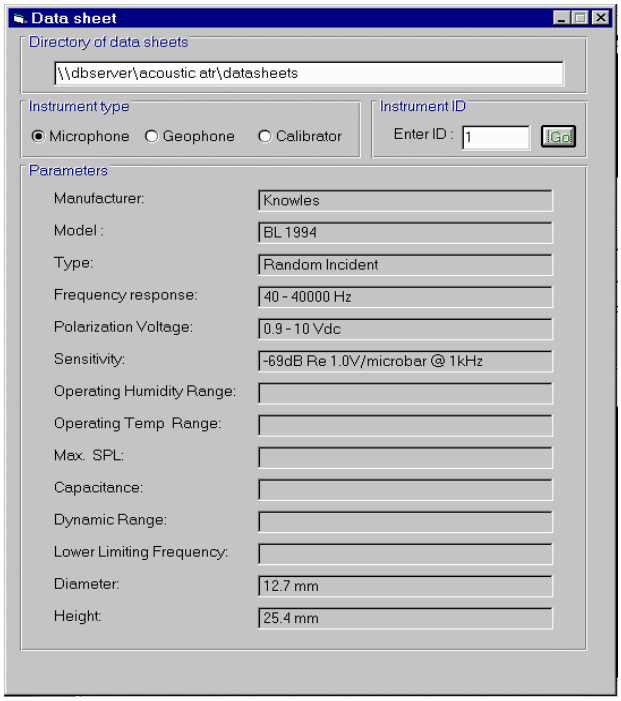

Figure 14. Microphone Data Sheet

6. Conclusion

The acoustic database is an integral component of the Acoustic Automatic Target Recognition (ATR) Lab, which is an ambitious project currently under development by the Acoustic Signal Processing Branch. The current emphasis is to archive data for all the various field experiments into the database and develop ATR tools to process and evaluate this data.

Although the current front-end program is fully functional and has been used on a daily basis, there are plans for enhancements to the program. The next phase of software development will include the integration of MATLAB and/or C algorithms for target detection, direction finding, classification, identification, and data fusion into the program. Additional reports will be published to provide detailed documentation on the database setup and other programming aspects of the front-end program.